5. Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 2001-2002; submitted by Michael E. Goebel, John J. Lyons, Brian W. Parker, Jessica D. Lipsky, and Anne C. Allen.

5.1 Objectives: As upper trophic level predators, pinnipeds are a conspicuous component of some Antarctic marine ecosystems. They respond to spatio-temporal changes in the physical and biological oceanography of the environments that they live in and are directly dependent upon availability of krill (*Euphausia superba*) for maintenance, growth, and reproduction during the austral summer. Because of their current numbers and their pre-exploitation biomass in the Antarctic Peninsula region and Scotia Sea, Antarctic fur seals, are recognized to be an important "krill-dependent" upper trophic level predator. In its ecosystem approach to monitoring and management of Antarctic resources, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has established standardized protocol for monitoring fur seal duration of trips to sea and offspring growth. The general objectives for pinniped research are to monitor population demography and trends, reproductive success, and status of pinnipeds throughout the summer months. The Antarctic fur seal, *Arctocephalus gazella*, is the most abundant pinniped at Cape Shirreff and our studies are focused to a large degree on this species. Fur seals are currently in a recovery phase after over-exploitation by the fur trade in the 1800's. They are considered "krill-dependent predators" as krill are an important component of their diet during the breeding season. Thus our studies are focused on foraging ecology, diving, foraging range, energetics, diet, and reproductive success of fur seals rearing offspring.

Pinniped research was conducted by the U.S. AMLR Program at Cape Shirreff, Livingston Island, Antarctica (62°28'S, 60°46'W) during the 2001-2002 season. In addition to our annual studies at Cape Shirreff, a census of Antarctic fur seal pups at known fur seal colonies in the South Shetlands was also conducted from 30 January-5 February. Results of that census are reported in section seven of this report.

The 2001/02 field season began with the arrival at Cape Shirreff of a four person field team via the R/V *Nathaniel B. Palmer* on 14 November 2001. Research activities were initiated soon after and continued until closure of the camp on 10 March 2002. Our specific research objectives for the 2001/02 field season were to:

A. Monitor Antarctic fur seal female attendance behavior (time at sea foraging and time ashore attending a pup);

B. Monitor pup growth in cooperation with Chilean researchers collecting length, girth, and mass for fur seal pups every two weeks throughout the research period;

C. Document fur seal pup production at designated rookeries on Cape Shirreff and assist when necessary Chilean colleagues in censuses of fur seal pups for the entire Cape and the San Telmo Islands;

D. Collect and analyze fur seal scat contents on a weekly basis for diet studies;

E. Collect a milk sample at each adult female fur seal capture for fatty acid signature analysis and diet studies;

F. Deploy time-depth recorders on adult female fur seals for diving studies;

G. Record at-sea foraging locations for adult female fur seals using ARGOS satellite-linked transmitters (deployments to coincide with the U.S.-AMLR Oceanographic Survey cruises);

H. Tag fur seal pups for future demographic studies;

I. Re-sight animals tagged as pups in previous years for population demography studies;

J. Monitor survival and natality of the tagged adult female population of fur seals;

K. Extract a lower post-canine tooth from adult female fur seals for aging studies;

L. Deploy a weather station for continuous recording of wind speed, wind direction, ambient temperature, humidity and barometric pressure during the study period; and

M. Record other tagged pinnipeds observed and any pinnipeds carrying marine debris (i.e. entanglements).

5.2 Accomplishments:

A. Female Fur Seal Attendance Behavior: Lactation in Otariid females is characterized by a cyclical series of trips to sea and visits to shore (attendance) to suckle their offspring. These cycles are commonly referred to as attendance patterns. Measuring changes in attendance patterns (especially the duration of trips to sea) of lactating Otariids is one of the standard indicators of a change in the foraging environment and availability of prey resources. Generally, the shorter the duration of trips to sea, the more resources a female can deliver to her pup during the period from birth to weaning.

We instrumented 28 lactating females from 5-12 December 2001. The study was conducted according to CCAMLR protocol (CCAMLR Standard Method C1.2 Procedure A) using VHF radio transmitters (Advanced Telemetry Systems, Inc., Model 7PN with a pulse rate of 40ppm). Standard Method C1.2 calls for monitoring of trip durations for the first six trips to sea. Presence or absence on shore was monitored for each female every 30 minutes for 30 seconds. All females were instrumented 1-2 days post-partum (determined by the presence of a newborn with an umbilicus) and were left undisturbed for at least their first six trips to sea. Pups were captured at the same time as their mothers, and were weighed, measured, and marked with an identifying bleach mark. The general health and condition of the pups were monitored throughout the study by making daily visual observations. The presence/absence was recorded for each female for the first six trips to sea.

The first female in our study to begin her foraging cycles did so on 10 December and last female to complete six trips to sea did so on 24 January. The mean trip duration for the combined first six trips to sea this year was 3.18 days (±1.21, N=166, range: 0.50-7.85) the second lowest mean since data collection began at Cape Shirreff in 1997/98 (Table 5.1, Figure 5.1; ANOVA, $df_{4,833}$, p<0.005). Mean trip duration was longer than last year (**00/01:** 2.71d ±0.83, N=168, range: 0.75-5.66; Bonferroni p=0.01) but not different from 1999/00 (**99/00:** 3.47d ±1.00, N=138, range: 0.60-8.25; Bonferroni p=0.53).

Mean duration for the first six, non-perinatal visits was 1.55 days (±0.62, N=166, range: 0.19-4.84) (Table 5.1, Figure 5.1; ANOVA, $df_{4,832}$, p<0.005). There was no difference in visit durations from 1999/00 (Bonferroni p=0.09) and 2000/01 (Bonferroni p=0.28). However, visit durations were longer than in 1998/99 (Bonferroni p=0.01) and 1999/00 (Bonferroni p=0.002).

The distribution of trip durations was skewed to longer trips in four (1999/00-2001/02) of the past five years (Table 5.1, Figure 5.2 for the last two years). Visit durations for all four years were likewise skewed (Table 5.1).

There was no difference in the postpartum mass of our attendance females from 1998/99 to 2001/02 (ANOVA, $df_{3,111}$, p=0.84). Females in the last four years were, however, larger than females in 1997/98, the first year of our studies (Figure 5.3a; ANOVA, $df_{4,142}$, p<0.0001; **97/98:** Mean=39.2kg ρ5.76, N=31; **98/99:** Mean=45.6kg ρ6.67, N=32; **99/00:** Mean=46.5kg ρ5.90, N=23; **00/01:** Mean=46.3kg ρ4.52, N=28; **01/02:** 45.2kg ρ7.32, N=28). This is because females in that year were sampled later (21-31 December) and late arriving females tend to be younger and smaller. The mass-to-length ratio, perhaps a better measure of condition, for all five years was not different (Figure 5.3b; ANOVA, $df_{4,142}$, p=0.79; **97/98:** Mean=0.338 ρ0.033, N=31; **98/99:** Mean=0.347 ρ0.041, N=32; **99/00:** Mean=0.346 ρ0.034, N=23; **00/01:** Mean=0.35kg ρ0.026, N=28).

B. Fur Seal Pup Growth: Measures of fur seal pup growth were a collaborative effort between the U.S. research team and Chilean researchers. Data on pup weights and measures were collected every two weeks beginning on 16 December and ending 1 March (six bi-weekly samples). Data were collected as directed in CCAMLR Standard Method C2.2 Procedure B. The results will be submitted to CCAMLR by Chilean researchers.

C. Fur Seal Pup Production: Fur seal pups (live and dead) and females were counted by U.S. researchers at four main breeding beaches (Copihue, Maderas, Cachorros, and Chungungo) on the east side of the Cape. Censuses were conducted every other day from 18 November 2001 through 10 January 2002. The maximum number counted (live and cumulative dead) at the combined four beaches in 2001/02 was 2435 on 6 January 2002 (Figure 5.4), an 8.3% increase over the maximum count for the same sites last year (**00/01:** 2,248 on 29 December 2000; **99/00:** 2,104 on 3 January 2000). The maximum count was taken as the mean of six separate counts of live pups (three each for two counters) on 6 January 2002 with the addition of total cumulative dead for that date (136 pups). There was a 0.7% difference in the mean count between observers (counter 1: mean=2291 pups, s.e.=6.6; counter 2: mean=2306 pups, s.e.=31.5).

The median date of pup births was 7 December, one day earlier than last year and the year before (99/00-00/01: 8 Dec) and three days earlier than first two years of our studies at Cape Shirreff (97/98-98/99: 10 Dec). Thus it appears that there is a trend for earlier parturition over the last five years. This may be due to earlier arrival of pregnant females or to fewer late-arriving females, which tend to be younger females (e.g. if recruitment of primiparous females were lower). The fact that pup production has increased on our study beaches over the same period would suggest that lower recruitment is not responsible for the earlier median date of parturition but rather earlier arrival is the reason.

D. Diet Studies: Information on fur seal diet was collected using three different sampling methods: collection of scats, enemas, and fatty acid signature analysis of milk. In addition to scats and enemas, an occasional regurgitation is found in female suckling areas. Regurgitations often provide whole prey that is only minimally digested. Scats are collected from around suckling sites of females or from captured animals that defecate while captive. All females that are captured to remove a time-depth recorder or satellite-linked transmitter (PTT) are given an enema to collect fecal material containing dietary information. In addition to diet information from captive animals, ten scats were collected opportunistically from female suckling sites every week beginning 20 December. The weekly scat sample is collected by systematically walking transects of female suckling areas and collecting any fresh scats within a short range of the observer. This method prevents any bias associated with the difference in visibility between krill laden scats, which are bright pink, and fish laden scats, which are gray to brown, and blend in with the substrate more easily.

In total, we collected and processed 103 scats, six enemas, and six regurgitations from 26 December 2001-28 February 2002. Diet samples that could not be processed within 24 hours of collection were frozen. All samples were processed by 8 March. Up to 30 krill carapaces were measured from each sample that contained krill. Otoliths were sorted, dried, identified to species and measured for length and width. The number of squid beaks were counted and preserved in 70% alcohol for later identification. A total of 2827 krill carapaces were measured. Most of these (87.4%) were from weekly scat collections; 94.2% (97 of 103) of the weekly scat samples collected contained krill. In addition, 4,546 otoliths from three species of myctophid fish were collected from 84.5% of the weekly scat collections (*Electrona antarctica*, n=1433; *Electrona carlsbergi*, n=875; *Gymnoscopelus nicholsi*, n=2238; plus an additional 390 unidentified otoliths). A total of 80 squid beaks (*Brachioteuthis picta*) were collected from 13.6% of the weekly samples.

The proportions of krill, fish and squid were different every year (Table 5.2, X^2=30.8, d.f.=6, p<0.0005). Results indicated more fish in the diet in December than in previous years (Figure 5.5). The December increase was primarily an increase in *Electrona antarctica* and *Electrona carlsbergi* and not in *Gymnoscopelus nicholsi* (Figure 5.6). The weekly proportions of the three most common fish species in fur seal diets at Cape Shirreff varied throughout our ten-week scat collection period. *E. antarctica* occurred in fur seal diets with a bimodal distribution (Figure 5.6) with peaks at week one (26 Dec-1 Jan) and week four (16-22 Jan) of collections. *E. carlsbergi* was most abundant week two (2-8 Jan). *Gymnoscopelus nicholsi* had very little occurrence in the diet until week five (23-29 Jan) and also had a bimodal distribution of occurrence (Figure 5.6). Squid was more common in the diet and, as in previous years, squid was confined primarily to scats collected in February (Figure 5.6).

The length and width of krill carapaces found in fur seal scats were measured in order to determine length distribution of krill consumed. Up to thirty carapaces from each scat were randomly selected and measured according to Hill (1990). The following linear discriminant function (Reid and Measures 1998) was applied to the carapace length (CL) and width (CW) to determine sex of individual krill:

$$D = -1.04 - 0.146(CL) + 0.265(CW)$$

Positive discriminant function values were identified as female and negative values male. Once the sex for each krill was determined the following regression equations from Reid and Measures (1998) were applied to calculate total length (TL) from the carapace length:

$$\text{Females: } TL = 15.3 + 2.09(CL)$$
$$\text{Males: } TL = 13.9 + 2.29(CL)$$

A total of 2,827 carapaces were measured from 111 scats, enemas, and regurgitations in 2001/02. Summary statistics are presented in Table 5.3. Data from 1999/00 and 2000/01 are also presented for comparison. Krill consumed by fur seals in 2001/02 was on average smaller than in 2000/01 (Table 5.3; ANOVA, d.f.$_{2,8291}$, F-ratio = 430.6, $p<0.0005$). The length distributions (in 2mm increments) for the last three years are presented in Figure 5.7. Smaller krill (<50mm) began appearing in fur seal scats in late January and by March krill in fur seal diets had a strongly bimodal length distribution (Figure 5.8).

E. Fatty Acid Signature Analysis of Milk: In addition to scats, enemas, and regurgitations, we collected 119 milk samples from 79 female fur seals. Each time a female was captured (either to instrument or to remove instruments), 30mL of milk was collected by manual expression. Prior to collection of the milk sample, an intra-muscular injection of oxytocin (0.25mL, 10 UI/mL) was administered. Milk was returned (within several hours) to the lab where two 0.25mL aliquots were collected and each stored in a solvent-rinsed glass tube with 2mL of chloroform with 0.01% butylated hydroxytoluene (BHT, an antioxidant). Samples were flushed with nitrogen, sealed, and stored frozen until later extraction of lipid and trans-esterification of fatty acids. Of the 119 samples, 24 were collected from perinatal females and 24 were collected from 16 females that had dive data for the foraging trip prior to milk collection.

F. Diving Studies: Eleven of our 28 females transmittered for attendance studies also received a time-depth recorder (TDR, Wildlife Computers Inc., Mark 7, 8.6 x 1.9 x 1.1cm, 27g) on their first visit to shore. All of them carried their TDR for at least their first six trips to sea. One of the 11 TDRs failed, thus only 10 records were collected for dive data for the first six trips to sea. In addition, all other females captured for studies of at-sea foraging locations also received a TDR. The total number of females with diving data for 2001/02 was 16. The total number of trips recorded on TDRs from 10 December 2001 – 16 February 2002 was 104.

G. Adult Female Foraging Locations: We instrumented 13 females with satellite-linked transmitters (ARGOS-linked Platform Terminal Transmitters or PTTs) from 24 December – 16 February. The number of females with PTTs was fewer than in previous years because of four PTTs that failed bench checks before deployment. Eight of the 13 were deployed to coincide with the U.S.-AMLR large-scale oceanographic survey. All 13 females carried a PTT for at least two trips to sea, 10 for three trips and one female, because she had numerous short trips to sea carried her PTT for six trips. Results of fur seal foraging location data analysis and interannual comparisons are pending.

H-J. Demography and Tagging: Together Chilean and U.S. researchers tagged 499 fur seal pups (262 females, 237 males) from 21 January – 7 March 2002. All tags placed at Cape Shirreff were Dalton Jumbo Roto tags with white tops and orange bottoms. Each pup was tagged on both fore-flippers with identical numbers (2501-2999). Tag 3000 was misprinted 2000 and not deployed. Most pups (388 or 77.8%) were tagged on the east side of the Cape from Playa Marko to Chungungo beach. A total of 111 pups (58 females, 53 males) were tagged at Loberia beach on the northwest side of the Cape.

In addition to the 499 pups tagged, we also tagged 37 adult lactating, previously untagged, females (231-264, 266, 267, 271) and three females that had previously been tagged (i.e. females 122, 053, and 638 had their tags replaced with 265, 270, and 272, respectively). All tags were placed on females with parturition sites on east side beaches (Copihue, Maderas, Cachorros, and Chungungo beaches).

Last year we added 34 adult females to our tagged population. These 34, when added to the females that returned in the previous season (n=161), gave an expected known tagged population of 195 for 2001/02 (Table 5.4). Of these, 191 (97.9%) returned in 2001/02 to Cape Shirreff and 174 (91.1%) returned pregnant (Figure 5.9). The return and pregnancy rates were the highest recorded in four seasons of adult female tag returns (Return rates: **98/99:** 83.8%, **99/00:** 94.0%, **00/01:** 90.2; Natality rates: **98/99:** 75.7%, **99/00:** 86.7%, **00/01:** 78.6; Figure 5.9).

Our tagged population of females returned (on average) two days earlier than last year. In 2000/01, the mean date of pupping for tagged females (which had a pup in both years) was 7 December (ρ6.96, N=139) and in 2001/02, for the same females, it was 5 December (ρ6.37, N=139). The median date of pupping for our tagged females for 2000/01 was 7 December and for 2001/02 it was 4 December. This result is earlier for both years than our estimates of the median date of pupping based upon pup counts for the season (see section C above). It suggests that our tagged population is slightly biased towards earlier arriving (and likely older) females. More importantly, however, is that both measures show a trend for an earlier date of parturition for Cape Shirreff fur seals.

This year we refined our tag re-sight protocol to enable us to better measure effort from year to year. The new protocol now requires systematic searches of defined sub-areas while "on the clock" and all tags observed are now recorded as systematic or opportunistic (tags observed while performing other research activities).

In 2001/02 we observed only seven yearlings (three females and four males that were tagged as pups in 2000/01; Table 5.5). This represents a much lower rate of return for yearlings than sighted last year (2000/01: 26 yearlings sighted from the 1999/00 cohort). Table 5.5 presents observed tag returns for four cohorts in their first year. Tag deployment, the total number placed and re-sighting effort for all four cohorts were similar and the variance is likely due to differences in the post-weaning physical and/or biological environment. The differences in return rates are not necessarily due to survival but may be due to other factors (e.g. physical oceanography of the region, over-winter prey availability or other factors) that influence whether animals return to natal rookeries in their first year.

We calculated the minimum percent survival for year one based upon tag re-sights for the first two years following tagging (Table 5.6). The survival values are adjusted based upon the probability that an individual would lose both tags. Tag loss (right or left) was assumed to be independent. The results presented are for the minimum percent survival because animals return for the first time to natal rookeries at different ages and the probability of returning at age 1, age 2, etc. may vary for different cohorts. Given similar re-sighting effort the three cohorts presented have return rates in the first two years that are very different (Figure 5.10). Most notable is that the 1999/00 cohort appears exceptional in its rate of return in both its first year and its second. The minimum survival to age-1 for the 1999/00 cohort was 25.0%. If the transition to nutritional independence and foraging conditions their first winter are critical to juvenile otariid survival (as suggested by York, 1994), then 1999/00 cohort experienced exceptionally good conditions at weaning and for their first winter at sea. The observed cohort differences are important whether due to survival or differences in dispersal that result in a different rate of return.

K. Tooth Extraction and Age Determination: We began an effort of tooth extraction from adult female fur seals for age determination in 1999/00. Tooth extractions are made using gas anesthesia (isoflurane, 2.5-5.0%), oxygen (4-10 liters/min), and midazolam hydrochloride (1cc). A detailed description of the procedure was presented in the 1999/00 annual report.

This year, from 16-29 January, we took a single post-canine tooth from 60 previously tagged females and 10 juvenile female fur seals. Two of the adult tagged females were tagged as pups at Seal Island and four of the juveniles were tagged as pups on Cape Shirreff. The teeth collected from these seven females will be used for validation of the aging technique. Females ranged in size from a mass of 28.6-55.2kg and length of 115-143cm. The mean total time captive was 14.0 min (ρ4.0) and the mean total time under anesthesia was 11.0 min (ρ 4.0, n=70). The time captive and the time under anesthesia both decreased over last year (18.0 and 14.0 min, respectively). The decreases were likely due to a more experienced crew.

Tooth extraction is the most invasive of our research techniques and could potentially affect reproductive success. We therefore have focused considerable effort in measuring the effects of extracting a tooth on attendance behavior (i.e. trip and visit durations), diving behavior, return and natality rate in the year following tooth extraction. Last year we reported some of our preliminary results, which showed no adverse affect on survival, natality, or subsequent trip durations. We compared return and natality of the first 79 females to have a tooth extracted to 94 females that did not. Females that had a tooth extracted in 1999/00 had a slightly lower rate of return (0.5% lower) and natality (2.3% lower) in 2000/01 than did females that did not have a tooth extracted (Percent return: 90.4 vs. 89.9; Natality: 88.2 vs. 85.9%). The differences were not significant (Return: X^2=0.015, d.f.=1, P=0.90; Natality: X^2=0.186, d.f.=1, P=0.67). This year females that had a tooth extracted last year (N=60) had higher return and natality rates than females that did not have a tooth extracted (N=131) (Percent return: 98.0 vs. 92.4%; Natality: 97.0 vs. 87.6%). The higher rates are likely due to the fact that we only extracted teeth last year from tagged females, whereas the year before 50% of the females that had a tooth extracted were previously untagged. Tagged females are more likely to be older than randomly selected untagged females in February (the month we collected teeth in 1999/00). Monitoring of return and natality for females that have had a tooth extracted will continue in the future to determine if the difference is statistically significant.

L. Weather at Cape Shirreff: A weather data recorder (Davis Weather Monitor II) was set up at the U.S.-AMLR field camp at Cape Shirreff from 18 November 2001 to 6 March 2002. The recorder archived wind speed and direction, barometric pressure, temperature, humidity, and rainfall at 15-minute intervals. The sampling rate for wind speed, temperature, and humidity was every eight seconds; the averaged value for each 15-minute interval was stored in memory. Barometric pressure was measured once at each 15-minute interval and stored. When wind speed was greater than 0, the wind direction for each 8-second interval was stored in one of 16 bins corresponding to the 16 compass points. At the end of the 15-minute archive interval, the most frequent wind direction was stored in memory.

Mean daily temperature at Cape Shirreff was (on average) 0.47θC warmer this year than in 2000/01 for the same time period (18 November-12 February). Mean temperature from 18 November 2001 to 6 March 2002 was 2.36θC ± 1.59 (N=10,240). Wind speed for the same time period was 15.7 km/hr ± 8.3 with a maximum gust to 72.0 km/hr on 14 December. Total measurable precipitation in 2001/02 was greater than previous years 2000/01 but with similar total number of days of measurable precipitation for the time period 21 December-24 February (**1998/99:** 59.6mm for 43 days, **1999/00:** 57.1mm for 35 days, **2000/01:** 56.0mm for 36 days, **2001/02:** 80.0mm for 43 days). Over-winter snow cover at the start of this season was considerably less than last year though we do not have a precise measure of this. We also do not know how much the diminished snow cover was due to lower over-winter accumulation and how much to an early thaw. The thaw was earlier this year. By the time fur seal pupping began in late November most of the snow had melted from breeding areas, as well as, in extensive areas behind breeding beaches. The reduced snow cover at the time of breeding had a pronounced affect on distribution of fur seals early in the season. Female fur seals tended to pup over a larger area and above the beaches more than in years with more snow cover.

M. Miscellaneous: Tagged Elephant Seals. We observed three tagged elephant seals in 2001/02. All three had plastic Dalton jumbo roto tags and were tagged at Sea Lion Island, Falkland Islands (Galimberti, pers. com.). Tag number, color, right or left rear flipper, age/sex class, and date of observation at Cape Shirreff were as follows:

A06 (yellow, left)/ A29 (yellow, right), adult female, 12 Feb 2002
Z05 (yellow, left)/ W17 (white, right), adult female (also dye marked: MANO on each side), 2 Feb 2002
F82 (orange, left), adult female, 9 Jan 2002

Entangled pinnipeds. We observed only one entangled juvenile male fur seal this season. The entanglement debris, a single nylon string was removed.

5.3 Preliminary Conclusions: The 2001/02 season was better for Antarctic fur seals by several measures than the 1997/98-1999/00 seasons. It was similar in some respects to last year but mean foraging trip duration for lactating females was slightly longer than in 2000/01. Fur seal pup production at U.S.-AMLR study beaches on Cape Shirreff increased by 8.3% over last year. The median date of pupping based on pup counts was one day earlier than the last two years and three days earlier than in 1997/98 and 1998/99. The mean arrival and parturition dates for our tagged female population was also two days earlier than last year. Over winter survival and return rates for adult females were higher than any previous year, at 97.9%. There was no change in arrival condition compared to previous years. Natality rates were also higher than in previous years (91.1%). Return rate for yearlings was low (1.4%) and comparable to that of the 1998/99 cohort (1.2%). The 1999/00 cohort, however, appears to be an exceptionally strong cohort (5.2% return as yearlings and 25% minimum percent survival for the first year based on two years of sighting data). The mean trip duration for adult females' first 6 trips to sea was slightly greater than last year (3.18 vs. 2.71 days) but still less than from 1997/98 to 1999/00 (4.19, 4.65, and 3.47 days, respectively). Fur seals this year had slightly more fish in their diet than in previous years. The mean length of krill in fur seal diet decreased this year over last year, reflecting the same results as found in net tows from our oceanographic survey. As our monitoring program at Cape Shirreff continues, we are collecting valuable data on post weaning survival and return of fur seal neonates. Poor juvenile survival has been implicated as a primary source of declines in other otariids (York, 1994). Data on juvenile survival from Cape Shirreff will lead to a better understanding of the oceanographic conditions that lead to successful recruitment and sustainability of otariid populations.

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5.5 References:

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Table 5.1. Summary statistics for the first six trips and visits (non-perinatal) for female Antarctic fur seals rearing pups at Cape Shirreff, Livingston Island, 1997/98 – 2001/02.

Year	Female N	N	Range	Median	Mean	St.Dev.	Skew[1]	SE Skew	S[1]	(+/-)
Trip durations:										
1997/98	30	180	0.50 -9.08	4.07	4.19	1.352	0.083	0.181	0.459	-
1998/99	31	186	0.48 -11.59	4.23	4.65	1.823	0.850	0.178	4.775	+
1999/00	23	138	0.60 -8.25	3.25	3.47	0.997	1.245	0.206	6.044	+
2000/01	28	168	0.75 -5.66	2.69	2.71	0.828	0.874	0.187	4.674	+
2001/02	28	166	0.50 -7.85	2.87	3.18	1.207	0.740	0.188	3.936	+
Visit durations:										
1997/98	30	179	0.46 -2.68	1.25	1.35	0.462	0.609	0.182	3.346	+
1998/99	31	186	0.21 -3.49	1.27	1.33	0.535	0.947	0.178	5.320	+
1999/00	23	138	0.10 -4.25	1.51	1.72	0.635	1.088	0.206	5.282	+
2000/01	28	168	0.44 -3.15	1.52	1.68	0.525	0.485	0.187	2.594	+
2001/02	28	166	0.19 -4.84	1.43	1.55	0.621	1.328	0.188	7.094	+

[1]Skewness: A measure of asymmetry of the distribution of the data. A significant positive value indicates a long right tail. Significance (S) is indicated when the absolute value of Skewness/Standard Error of Skewness (SE) is greater than two.

Table 5.2. Results of a contingency table on the proportions of major prey types (krill, fish, and cephalopods) in Antarctic fur seal scats and enemas collected at Cape Shirreff, Livingston Island in four years of collections, 1998/99 through 2001/02 (X^2=30.8, d.f.=6, P<0.0005). Reject H_o: The proportions of krill, fish, and squid in the diet are homogeneous in the four years of study.

	1998/99		**1999/00**		**2000/01**		**2001/02**	
Prey	**Observed**	**Expected**	**Observed**	**Expected**	**Observed**	**Expected**	**Observed**	**Expected**
Krill	84	74.2	94	105.0	104	84.0	111	129.0
Fish	32	45.1	71	64.2	39	51.1	97	78.6
Squid	12	8.7	17	12.3	2	9.8	15	15.1

Table 5.3. Krill length (mm) in fur seal diet from 1999/00 - 2001/02. Data are derived from measuring length and width of krill carapaces found in fur seal scats and applying a discriminant function to first determine sex before applying independent regression equations to calculate total length.

	1999/00:			**2000/01:**			**2001/02:**		
Krill Length (mm)	**All Krill**	**Female**	**Male**	**All Krill**	**Females**	**Males**	**All Krill**	**Females**	**Males**
N:	2528	1623	905	2941	1578	1363	2826	1983	843
Median:	50.8	52.9	48.3	52.9	52.9	52.8	55.0	55.0	52.8
Mean:	50.6	52.0	47.9	53.1	53.6	52.5	53.8	54.3	52.4
St. Dev.:	4.46	3.31	5.00	3.82	3.57	4.02	4.44	3.59	5.77
Maximum:	59.7	59.2	59.7	39.1	40.4	39.1	64.3	63.4	64.3
Minimum:	13.9	40.4	13.9	64.3	63.4	64.3	36.8	38.3	36.8
Sex Ratio (M:F):	1:1.8			1:1.2			1:2.4		

Table 5.4. Tag returns and pregnancy rates for adult female fur seals at Cape Shirreff, Livingston Island, 1998/99 – 2001/02.

Year	Known Tagged Population[1]	Returned	Pregnant	% Return	% Pregnant	Tags Placed	Primaparous females tagged as pups
1997/98						37[2]	0
1998/99	37	31	28	83.8	90.3	52	0
1999/00	83	78	72	94.0	92.3	100	0
2000/01	173	156	136	90.4	87.2	35	0
2001/02	195[3]	191	174	97.9	91.1	42	2

[1]Females tagged and present on Cape Shirreff beaches the previous year.
[2]Includes one female present prior to the initiation of current tag studies.
[3]Includes one female tagged as an adult with a pup in 1998/99, which was present in 1999/00 but was never observed in 2000/01.

Table 5.5. A comparison of first year tag returns for four cohorts: 1997/98 – 2000/01. Values in parentheses are percent total tagged.

Cohort	Total Tags Placed	Tag Returns in Year 1 (%) Total	Males	Females
1997/98	500	22 (4.4)	10 (2.0)	12 (2.4)
1998/99	500	6 (1.2)	5 (2.0)	1 (0.4)
1999/00	500	26 (5.2)	15 (3.0)	11 (2.2)
2000/01	499	7 (1.4)	4 (1.7)	3 (1.1)

Table 5.6. Tag returns and minimum percent survival for three cohorts, 1997/98 – 1999/00 using only the first two years of re-sight data for each cohort. Assuming cohort return rates correlate with survival and are similar for each cohort, our data show survival to age-1 varies considerably.

	1997/98			1998/99			1999/00		
	Females	**Males**	**TOTAL**	**Females**	**Males**	**TOTAL**	**Females**	**Males**	**TOTAL**
Sightings:									
Sighted in Year 1:	12	10	22	1	5	6	11	15	26
Additional Tags Sighted in Year 2:	20	10	32	6	7	13	53	40	93
Minimum survival in year 1:	32	20	54[1]	7	12	19	64	55	119
Tag loss:									
Unknown tag status:	2	1	3	0	2	2	1	3	4
Both tags present:	14	13	29	6	6	12	48	42	90
Missing 1 tag:	16	6	22	3	2	5	15	10	25
Probability of missing one tag:	0.53	0.32	0.43	0.33	0.25	0.29	0.24	0.19	0.22
Probability of missing both tags[2]:	0.28	0.10	0.19	0.11	0.06	0.09	0.06	0.04	0.05
Survival estimates:									
Minimum % Survival 1st year:	12.80	8.00	10.8	2.8	4.8	3.8	27.6	20.6	23.8
Adj. Min. % Survival for year 1[3]:	16.44	8.80	**12.8**	3.1	5.1	**4.1**	29.2	21.4	**25.0**

[1]Includes two sightings of seals of unknown sex.
[2]Assumes tag loss is independent for right and left tags.
[3]Minimum percent survival adjusted for double tag loss.

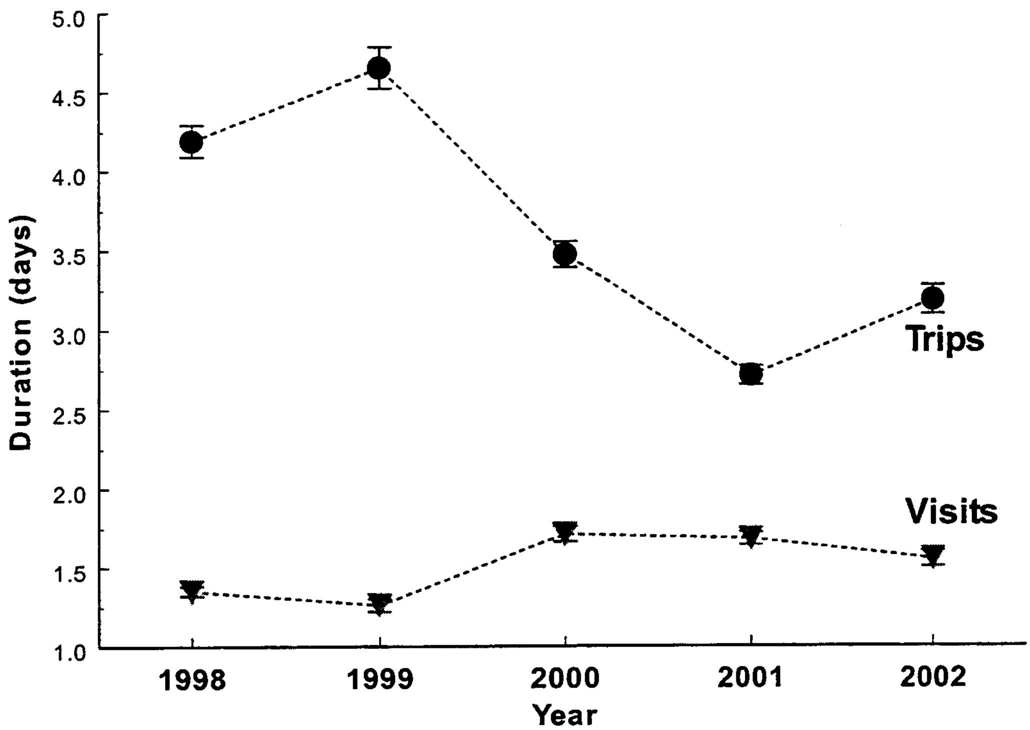

Figure 5.1. Antarctic fur seal trip and visit durations for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition for four years (**1997/98:** $N_{Females} = 30$, $N_{Trips} = 180$; **1998/99:** $N_{Females} = 31$, $N_{Trips} = 186$; **1999/00:** $N_{Females} = 23$, $N_{Trips} = 138$; **2000/01:** $N_{Females} = 28$, $N_{Trips} = 168$; **2001/02:** $N_{Females} = 28$, $N_{Trips} = 166$). Sample sizes for visits are the same as trips.

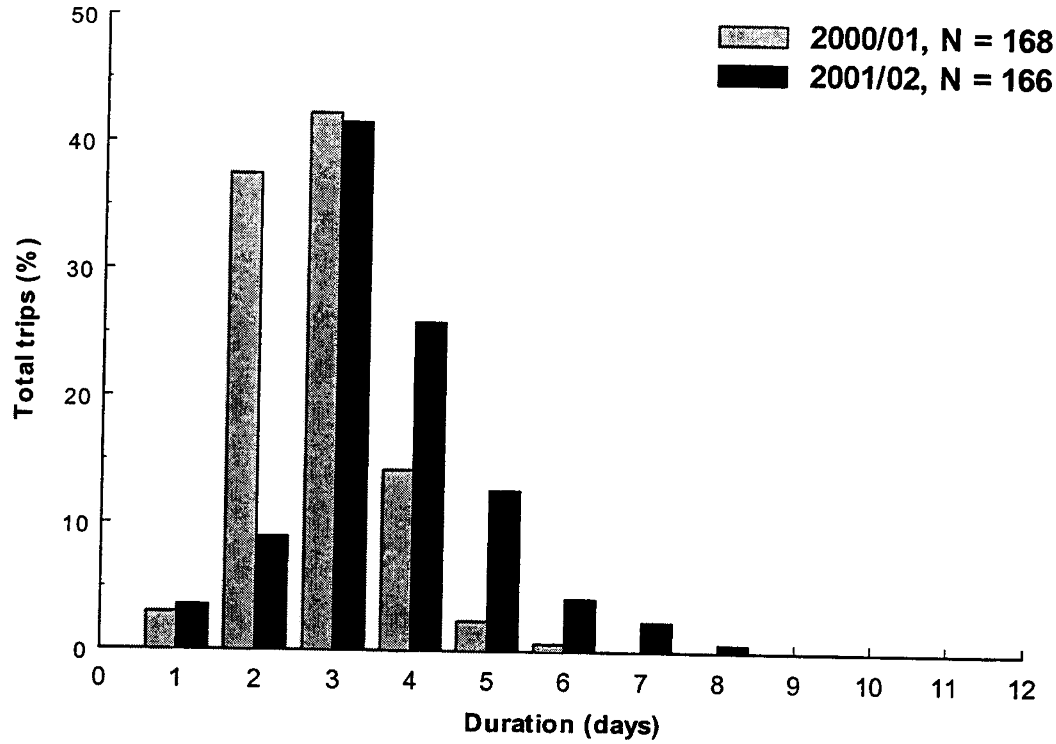

Figure 5.2. The distribution of Antarctic fur seal trip durations at Cape Shirreff, Livingston Island for the last two years (2000/01-2001/02).

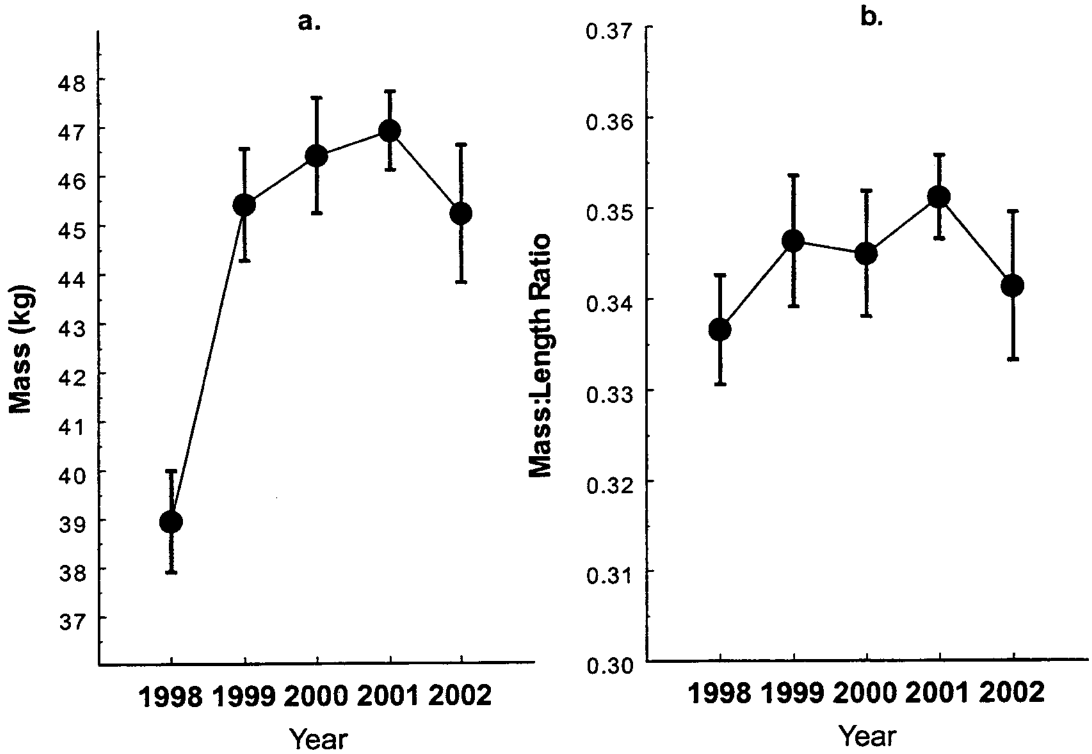

Figure 5.3. The mean mass (a.) and mass:length ratio (b.) for CCAMLR Attendance Study females for 1997/98 – 2001/02 (1997/98: **N=31,** 1998/99: **N=32,** 1999/00: **N=23,** 2000/01: **N=28,** 2001/02: **N=28).**

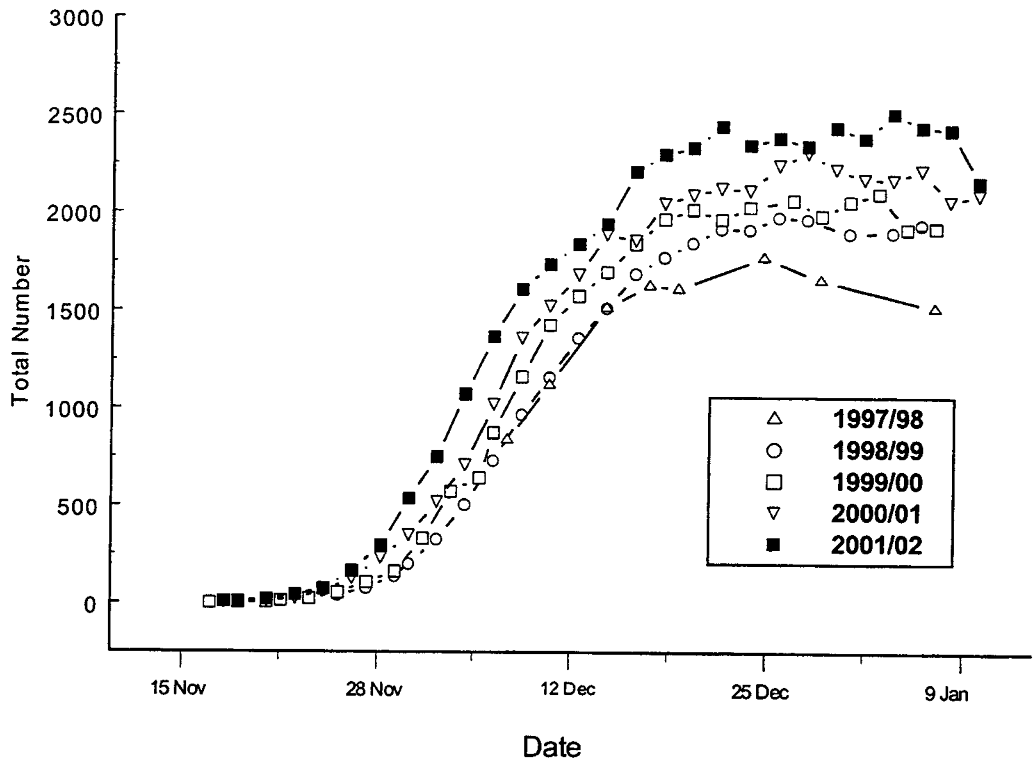

Figure 5.4. Antarctic fur seal pup production at U.S.-AMLR study beaches, Cape Shirreff, Livingston Island, 1997/98-2000/02.

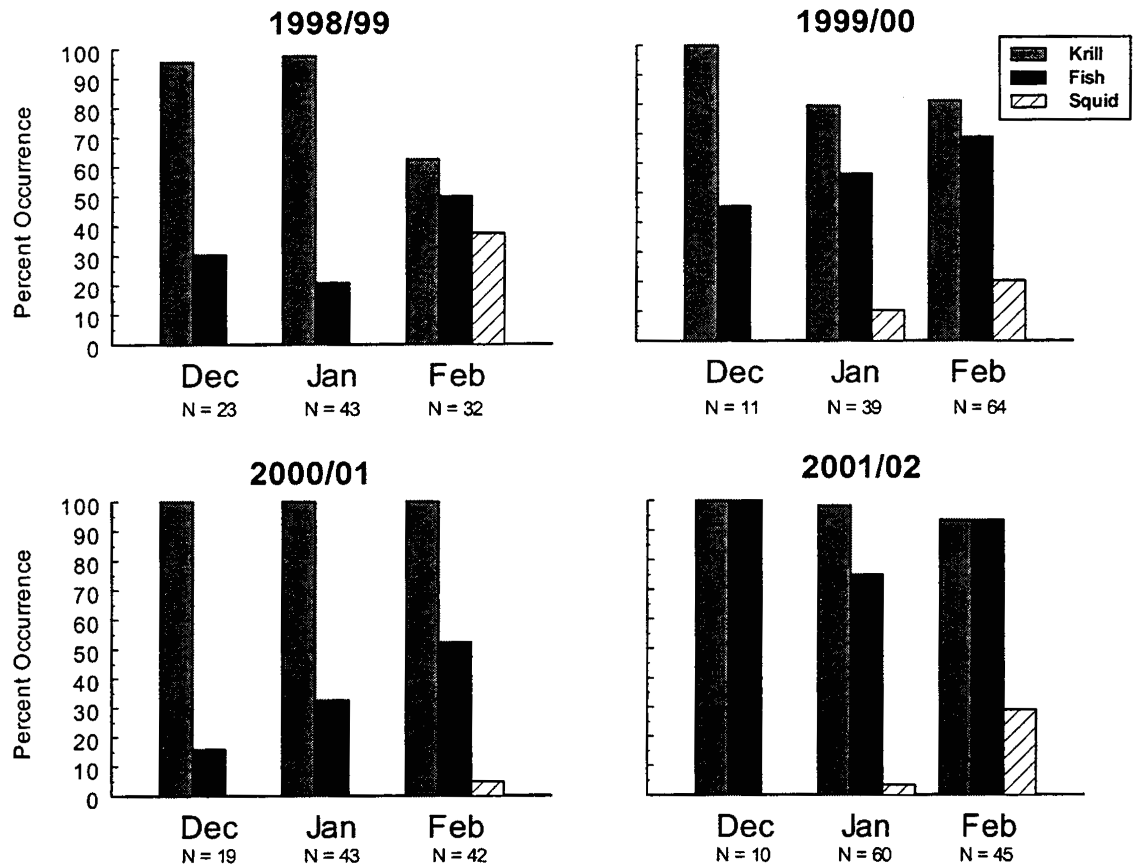

Figure 5.5. The percent occurrence of primary prey types (krill, fish, and squid) from December through February for Antarctic fur seal scats and enemas collected from female suckling areas at Cape Shirreff, Livingston Island for 1998/99 through 2001/02.

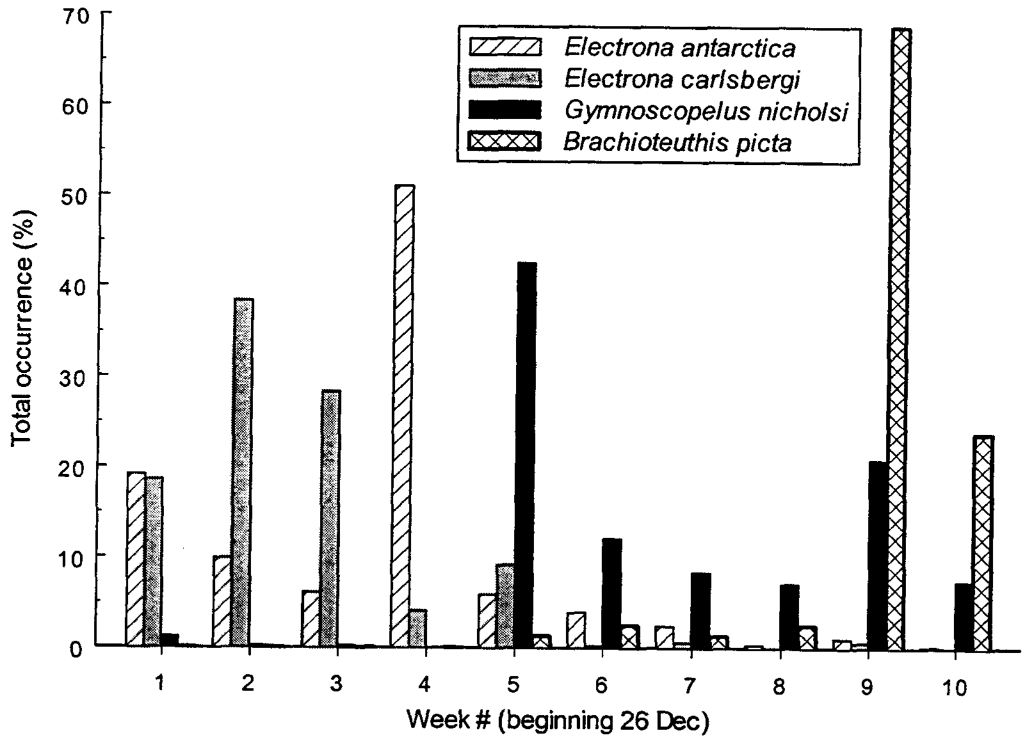

Figure 5.6. The weekly percent occurrence of the primary non-krill species found in fur seal diets at Cape Shirreff, Livingston Island in 2001/02. The four species are *Electrona antarctica*, *Electrona carlsbergi*, *Gymnoscopelus nicholsi*, and *Brachioteuthis picta*. The first three species are myctophid fish (lantern fish) and the fourth species is a cephalopod (squid).

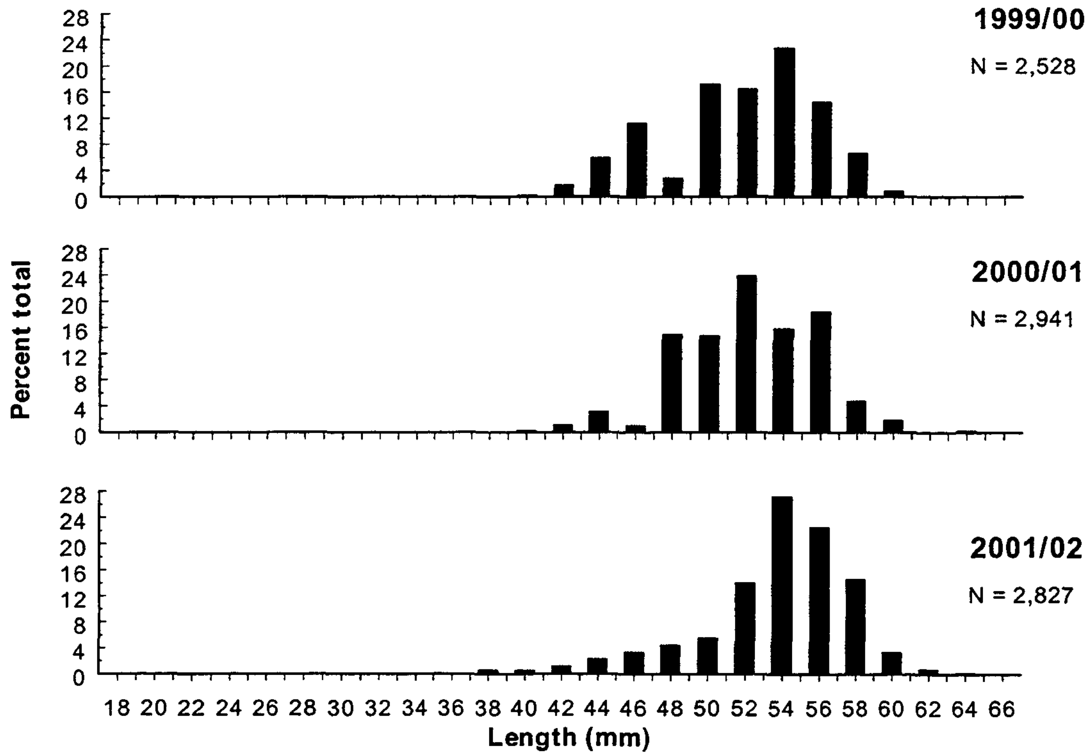

Figure 5.7. The size distribution of krill in Antarctic fur seal diet at Cape Shirreff, Livingston Island in 1999/00 and 2001/02.

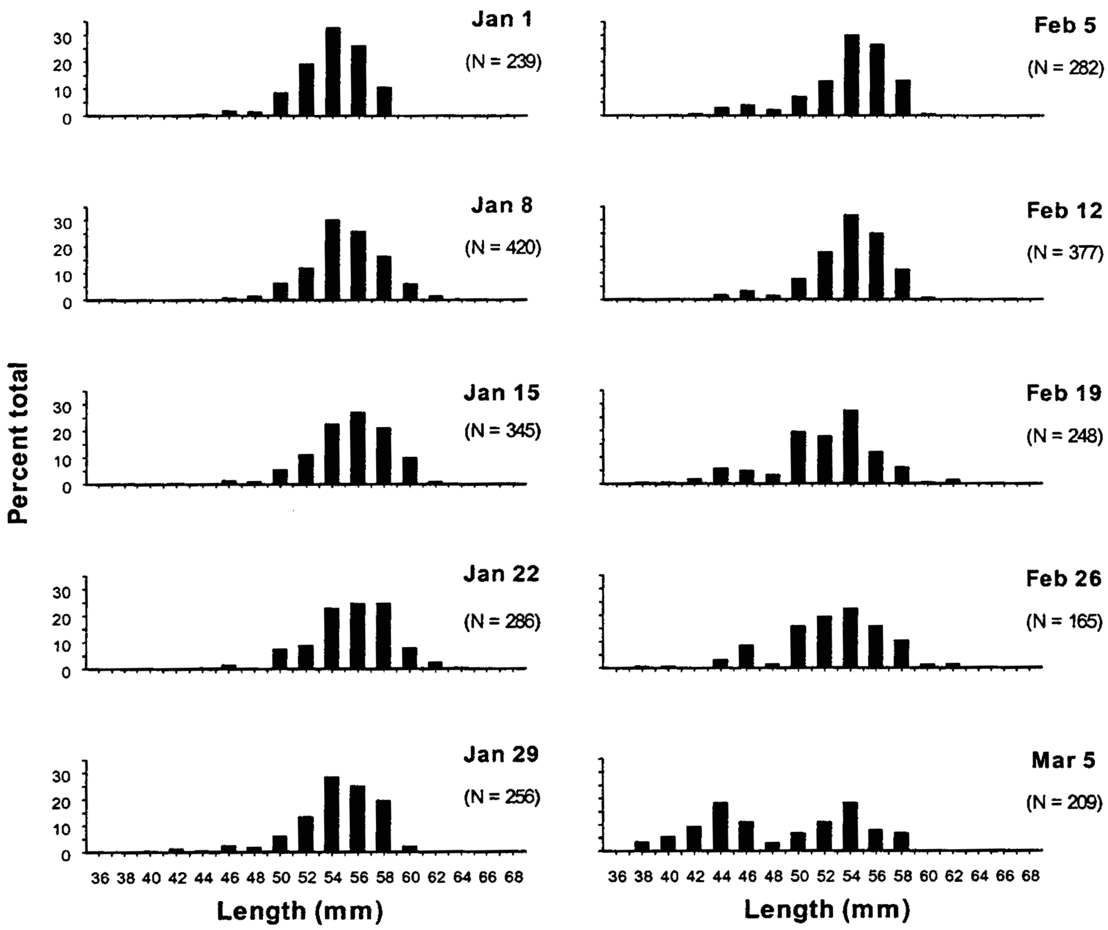

Figure 5.8. Weekly size distribution of krill (*Euphausia superba*) in Antarctic fur seal diet at Cape Shirreff, Livingston Island in 2001/02. Each plot represents one week of krill carapace measurements. The date on each plot is the last day of the week (e.g. Jan 1: the week 26 Dec 2001-1 Jan 2002). The number of krill carapaces measured for each week is given in parentheses. Large area oceanographic surveys (west area grid) by the R/V *Yuzhmorgeologiya* were conducted 16-19 January and 24-27 February (Weeks 4 and 8 in this plot; 22 Jan and 26 Feb).

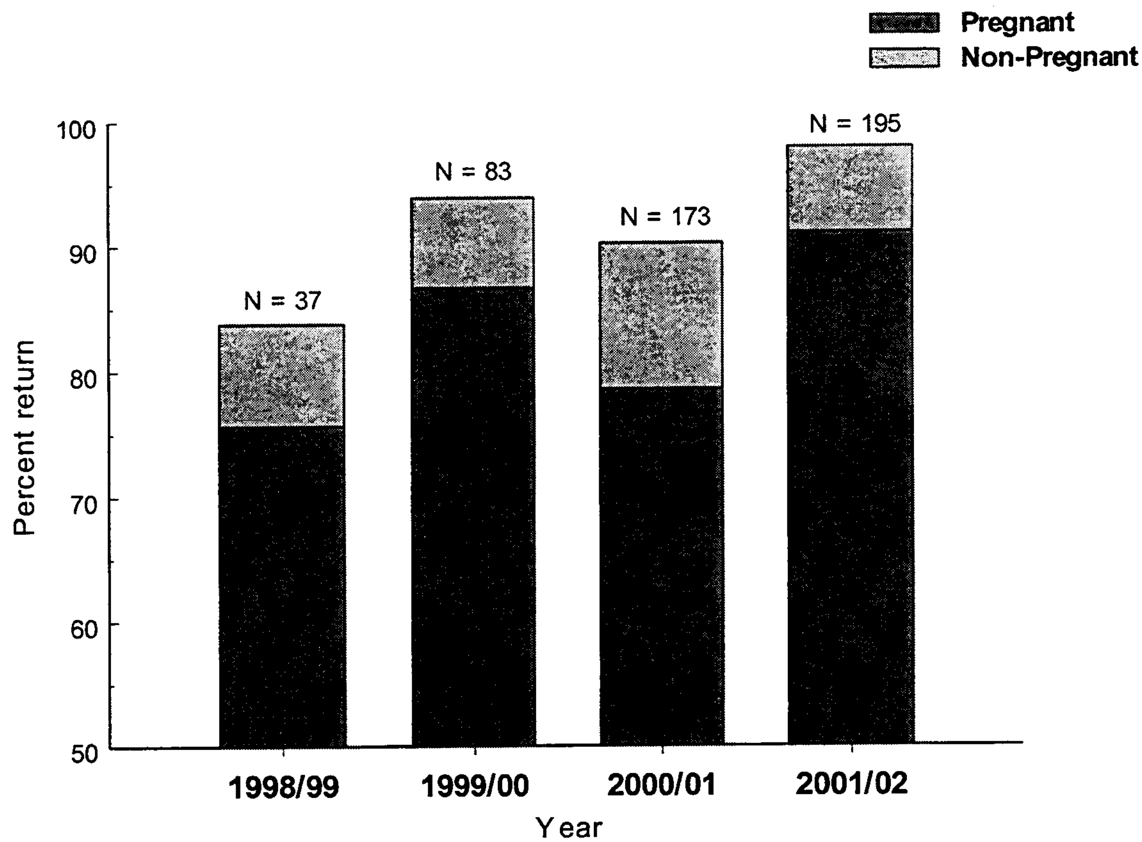

Figure 5.9. Adult female Antarctic fur seal tag returns for four years (1998/99-2001/02) at Cape Shirreff, Livingston Island.

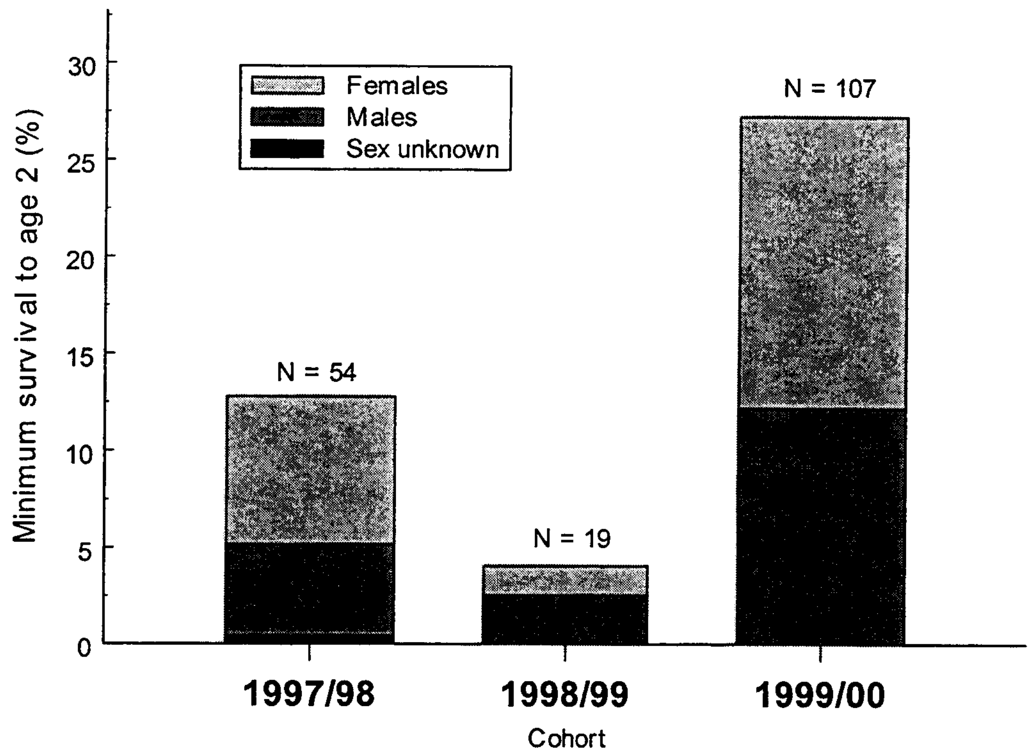

Figure 5.10. Minimum survival to age-1 based on tag returns for the first two years for three cohorts (1997/98, 1998/99, and 1999/00) of fur seals tagged as pups at Cape Shirreff, Livingston Island. Not all pups that survive their first year return as yearlings or two year olds, thus our estimates represent a minimum survival. Tag re-sight effort is assumed to be the same for all cohorts.